

Characterization of Photonic Cristal Cavities: Investigation on the Coupling between Microresonators and Waveguides

P. Pottier, X. Letartre, C. Seassal, C. Grillet, P. Rojo-romeo, P. Viktorovitch, J. Brault, M. Gendry
Laboratoire d'Electronique, Optoélectronique et Microsystèmes - UMR CNRS 5512 - Ecole Centrale de Lyon
36, avenue Guy de Collongue, BP 163, F-69131 ECULLY Cedex, FRANCE

M. Le Vassor D'Yerville, D. Cassagne, C. Jouanin
Groupe d'Etude des Semiconducteurs - UMR CNRS 5650 - Université Montpellier II
Place Eugène Bataillon, F-34095 MONTPELLIER Cedex 05, FRANCE

Photonic crystals (PC) are recognised as candidates to provide an effective control of light at micrometer size. In particular, for applications in the fields of optical telecommunications and interconnects, they can be used to elaborate photonic integrated circuits comprising sources, detectors, modulators, wavelength filters, and waveguides. As they can be fabricated on semiconductor layers using mature microelectronic and optoelectronic technologies, two-dimensional PC (2D PC) have recently been the subject of widespread theoretical and experimental investigation. In this case the vertical confinement is ensured by index contrast with substrate and cladding layers. PC-based integrated photonics will be at hand if we can control the properties of microresonators and waveguides and then the coupling between this two building blocks.

In this work, we report on properties of PC-based microcavities fabricated on InP suspended membranes. Their characterization is based on the observation of diffracted photoluminescence (PL) [1]. In order to generate a PL signal, a light beam is focused inside the microcavity. Mode spectra are then extracted from the light that is diffracted by holes in free space. Comparison is made with theoretical calculations obtained by a 3D plane wave method.

We investigate the influence of several parameters (cavity shape, PC filling factor...) on the spectral properties of PC cavities (figure 1). Modes frequencies and quality factor are particularly addressed. Then, modal properties of PC waveguides are measured. In our experiments, the waveguides are closed at both ends (by PC holes) in order to induce Fabry-Perot oscillations of guided modes in the resultant linear cavity (figure 2). The spectral response of the latter leads to the determination of group velocity and propagation losses of waveguided modes. Finally, coupling experiments are performed between a rectangular PC cavity and a PC waveguide. Light is generated inside the cavity and the resulting PL spectrum is measured (figure 3). When a waveguide is positioned near the cavity, some modes, previously diffracted, are no more observed, indicating a coupling of the light in the waveguide.

[1] : P. Pottier, C. Seassal, X. Letartre, J.-L. Leclercq, P. Viktorovitch, D. Cassagne, and C. Jouanin, *J. Lightwave Technol.* **17**, 2058 (1999).

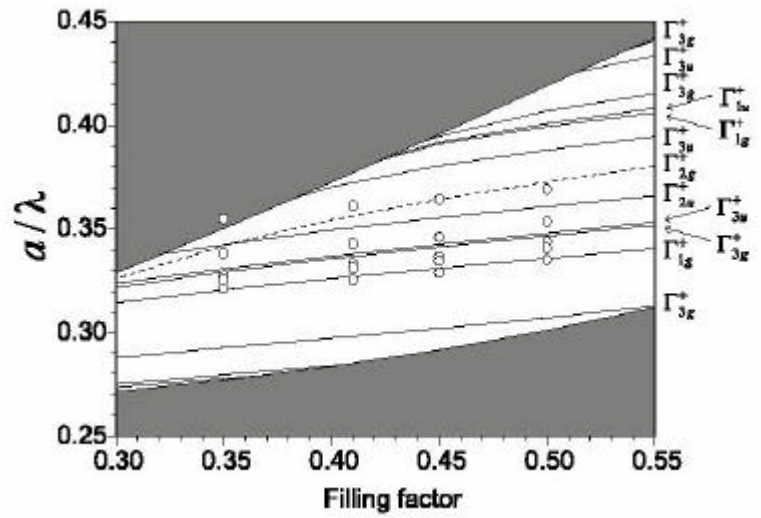


Figure 1 is a line graph showing the normalized power spectrum $|P_L|$ (in arbitrary units, u.a.) on the y-axis versus Wavelength (in nm) on the x-axis. The x-axis ranges from approximately 1350 nm to 1650 nm, with major ticks at 1400, 1500, and 1600. The y-axis ranges from 0.0 to 3.0, with major ticks at 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0. Two curves are plotted: a dotted line representing the 'Open Waveguide' and a solid line representing the 'Closed Waveguide'. The 'Open Waveguide' curve has a broad peak of approximately 1.6 at 1550 nm and a smaller peak of approximately 0.9 at 1400 nm. The 'Closed Waveguide' curve has a very sharp, high peak of approximately 3.0 at 1580 nm and a smaller peak of approximately 1.9 at 1400 nm. Both curves show several smaller oscillations between the main peaks.

The left panel is a scanning electron micrograph (SEM) of a photonic crystal slab. It features a periodic array of circular holes in a slab, with a central rectangular defect cavity. A scale bar in the bottom left corner indicates 10 μm.

The right panel is a plot of photoluminescence intensity I_{PL} (in arbitrary units, u.a.) versus Wavelength (nm). The x-axis ranges from 1450 to 1650 nm, and the y-axis ranges from 0 to 8 u.a. Two curves are shown: a solid line for 'Cavity+Waveguide' and a dotted line for 'Cavity'. The 'Cavity' curve shows three prominent peaks at approximately 1495 nm, 1575 nm, and 1605 nm. The 'Cavity+Waveguide' curve shows broader, lower-intensity peaks at the same wavelengths, indicating light leakage from the cavity into the waveguide.

Figure 3: Photoluminescence spectra of a rectangular PC cavity: alone (straight line), with a PC waveguide as shown on the SEM micrograph (doted line)